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(54) Unbalanced load detection system and method for a household appliance.

(57) Load unbalance in an inverter driven washing machine is detected by examining the ripple in the DC inverter bus current. Ripple above a predetermined level is indicative of load unbalance. If the ripple indicates the load is unbalanced, the distribution cycle of the washing machine is attempted again in an attempt to more nearly balance the clothes. After a certain number of tries, if the load is still unbalanced the spin cycle is aborted. If the ripple falls below a predetermined level before the maximum number of tries is reached, the spin cycle is started. The frequency of operation is checked during the spin cycle to adjust the cycle time to the particular degree of load balance achieved.

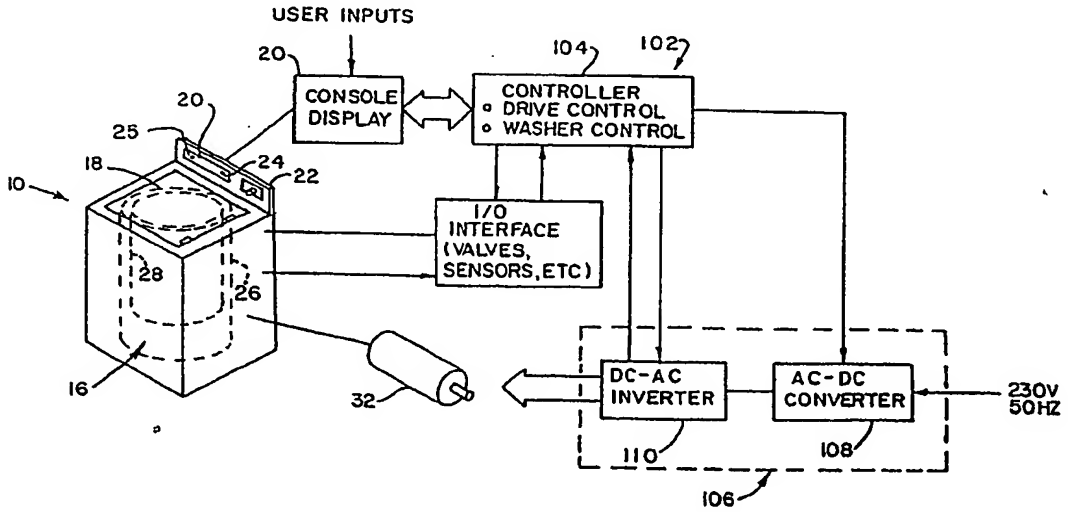

FIG. 1.

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EUROPEAN SEARCH REPORT

Application Number

EP 90 63 0078

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X,A	FR-A-2 331 883 (PHILIPS) * the whole document *	1-5,10, 12-16, 20-26,6, 7,9,17,19	D 06 F 37/20
X,A	US-A-4 765 161 (WILLIAMSON) * the whole document *	1-5,10, 12-16, 20-26, 6-9,11, 17-19, 27-29	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

D 06 F

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	09 October 91	MADSEN P.A.

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
Y: particularly relevant if combined with another document of the same catagory
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention

E: earlier patent document, but published on, or after the filing date
D: document cited in the application
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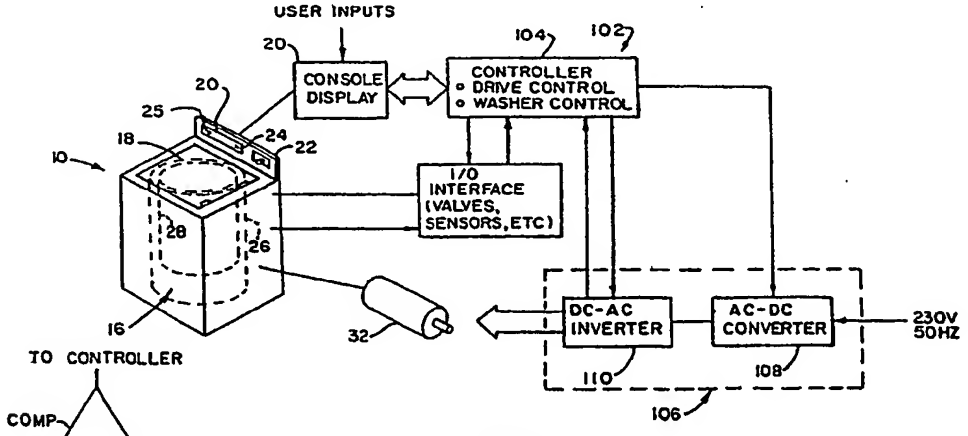

FIG. 1.

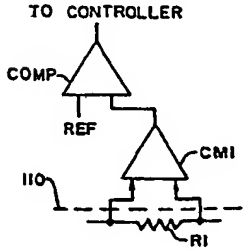

FIG. 1A.

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Background of the Invention

This invention relates to electronic control systems for household appliances and, more particularly, to such systems for sensing and correcting load imbalances in a washing machine and aborting a machine cycle if the imbalance cannot be corrected.

Unbalanced loads in washing machines cause excessive mechanical and electrical stresses. It is thus important to be able to sense when an unbalanced load condition exists and to correct it. Sensing of load balance using either mechanical or solid state sensors (load cells, for example) is costly and reduces system reliability. Load balance can also be detected directly by sensing the motor/drum speed of the machine, but this requires costly tachogenerators. In addition, most sensing techniques require extra electrical leads either to the motor or to the rest of the system, which reduces both the reliability and cost-effectiveness of the system.

Summary of the Invention

Among the several objects and features of the present invention may be noted the provision of an improved system and method for detecting imbalance of the load in an electric motor driven, drum-type washing machine.

Another object is the provision of such a system and method which attempts to correct an imbalance situation before the spin cycle is started.

A further object is the provision of such a system and method which senses imbalance during the spin cycle and corrects the parameters of the spin cycle to compensate.

A fourth object is the provision of such a system and method which enters the machine's spin cycle only if no imbalance is sensed, or a sensed imbalance corrected, and to otherwise terminate machine operation.

A fifth object is the provision of such a system and method which senses the motor frequency during the spin cycle, as an indication of load imbalance.

A sixth object is the provision of such a system and method which sets the length of the spin cycle as a function of any sensed load imbalance.

A seventh object is the provision of such a system and method which terminates the spin cycle if too great a load imbalance is sensed.

An eighth object is the provision of such a system and method which is implemented utilizing existing components in the machine so as to not increase the cost or complexity of the machine.

Other objects and features will be in part apparent and in part pointed out hereinafter.

Briefly, a method of the present invention is directed to sensing and correcting load imbalance in a household appliance such as a washing machine, which appliance has an operational cycle divided into at least a load distribution portion in which the load is distributed with respect to an axis and a post-distribution portion in which the load revolves about the axis of rotation at a relatively high speed. The load is driven by an induction motor powered by a direct current inverter drive. The method includes the step of, at a predetermined point in the load distribution portion of the operational cycle of the appliance, energizing the motor at a predetermined frequency to drive the load at a predetermined nominal speed. The ripple in the direct current through the inverter drive while the motor is energized at the predetermined frequency is examined and compared with a predetermined reference. The post-distribution portion of the operational cycle is started only if the ripple falls below the predetermined reference.

A washing machine of the present invention is capable of sensing and correcting load imbalance. The machine has an operational cycle which includes a distribution cycle and a spin cycle. It includes a drum in which items to be washed are placed, which drum has an axis of rotation about which the drum is rotatable. An induction motor is operatively connected to the drum to drive the drum about its axis of rotation and a direct current inverter drive is provided for powering the motor. A control circuit controls the motor by way of the inverter drive. More particularly the control circuit controls the motor to run the machine through its operational cycle including the distribution cycle in which the items to be washed are distributed about the drum and the spin cycle in which water is removed from the items to be washed. The control circuit is responsive to the machine reaching a predetermined point in the operational cycle for energizing the motor at a predetermined frequency to drive the drum at a predetermined nominal speed. The control circuit examines the ripple in the direct current through the inverter drive when the motor is energized at the predetermined frequency and compares the ripple with a predetermined reference. The control circuit is responsive to the comparison of the ripple with the predetermined reference to start the spin cycle only if the ripple falls below the predetermined reference.

A control system for a washing machine of the present invention is capable of sensing and correcting load imbalance. The machine itself has an

operational cycle which includes a distribution cycle and a spin cycle. The machine also has a drum in which items to be washed are placed, the drum having an axis of rotation about which the drum is rotatable. An induction motor is operatively connected to the drum to drive the drum about its axis of rotation. A direct current inverter drive powers the motor. The control system is responsive to the machine reaching a predetermined point in the operational cycle for energizing the motor at a predetermined frequency to drive the drum at a predetermined nominal speed. The system examines the ripple in the direct current through the inverter drive when the motor is energized at the predetermined frequency and compares the ripple with a predetermined reference. The control system is responsive to the comparison of the ripple with the predetermined reference to start the spin cycle only if the ripple falls below the predetermined reference.

Brief Description of the Drawings

Fig. 1 is a block diagram of a washing machine control system of the present invention;

Fig. 1A is an electrical schematic of a current sensing circuitry in the system of Fig. 1;

Fig. 2 is a flowchart representing operation of a washing machine during the distribution cycle;

Figure 3 is a graph representing bus current in the inverter drive by means of which load imbalance is sensed; and,

Fig. 4 is a flowchart of the operation of the washing machine in the spin cycle.

Corresponding reference characters represent corresponding parts throughout the several views of the drawings.

Description of the Preferred Embodiment

The present invention is embodied in a top load washing machine 10 (Fig. 1) although the invention is not limited to any particular type of washing machine or any particular washing machine construction. Washing machine 10 is a vertical axis agitator type washing machine having a cabinet 16. A hinged lid 18 is provided in the usual manner on the top of the machine for access to the interior of the machine.

A control panel or control console 20 is located at the top rear portion of washing machine 10. Arranged on console 20 are various user selectable controls including a timer 22 and temperature selector 24. Other controls, such as a control switch 25 may be provided. It will be understood that console 20 provides user access to a plurality of appliance performance functions or options among which the user of the appliance may choose. The controls may be implemented by means of push-button switches, touch pads or other suitable user operable switches.

A fluid containing tub 26 is disposed within washing machine 10. A perforated basket or drum 28 is mounted within tub 26 for rotation about a vertical axis. An induction motor 32 is operatively connected to drum 28 to drive the drum through its necessary motions in the operational cycle of the machine. It should be understood that the operational cycle includes a distribution cycle in which clothes to be washed are distributed in the tub and a spin cycle, which follows the distribution cycle, in which water is removed from the clothes in the drum. Those skilled in the art will recognize that a variety of drive arrangements can be utilized with motor 32. Motor 32 may even be directly attached to either the agitator or spin basket of the washing machine to directly control operation of the washing machine. As will be appreciated by those skilled in the art, the washing machine described herein is by way of illustration only. In practice machine 10 may comprise any of a variety of commercially available appliances.

Motor 32 is preferably any of a variety of commercially available induction motors. For example, motor 32 may be a single-phase AC induction motor designed for single-phase, 0 -500 hertz operation with a power rating of 500 watts.

The drive system of the present invention controls the functioning of washing machine 10, including the functioning of electric motor 32. A user of the appliance selects from among the various performance options of the appliance and the appliance is controlled by the drive system to operate in accordance with the selected options. The selection means by which the user selects from among the performance options comprises the control console 20. As noted, console 20 includes a plurality of switches, such as switches 24 and 25, by which the user selects those performance options which the user wants the appliance to perform.

The drive system includes a first control means 102 which in the present embodiment is a controller or control circuit 104. It should be understood that the control circuit can include both discrete and integrated devices as will be apparent to those of ordinary skill in the art in view of the present disclosure. The control circuit is responsive to the switch settings or options selected by the user. The control circuit monitors the operational status of the appliance through the inputs from various conventional sensors (not shown) such a door position sensor, a sensor indicating the water level in tub 28, and a sensor indicating the water temperature in the tub. In response to these various user

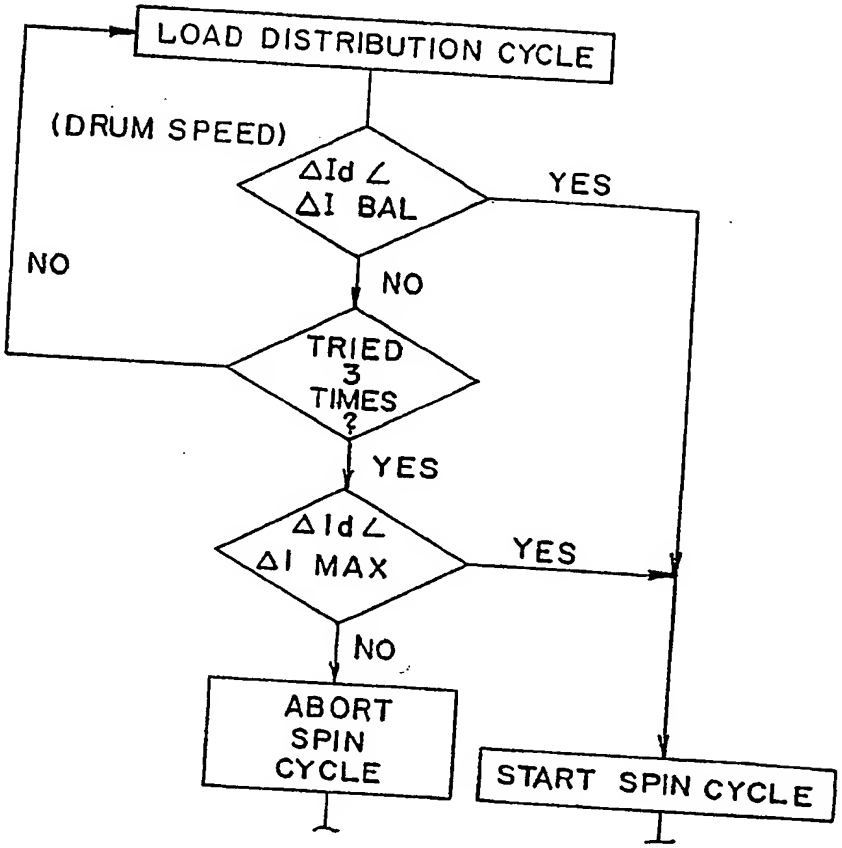
LOAD DISTRIBUTION CYCLE
(DRUM SPEED)
ΔId ∠ ΔI BAL
YES
NO
NO
TRIED 3 TIMES ?
YES
ΔId ∠ ΔI MAX
YES
NO
ABORT SPIN CYCLE
START SPIN CYCLE

FIG. 2.

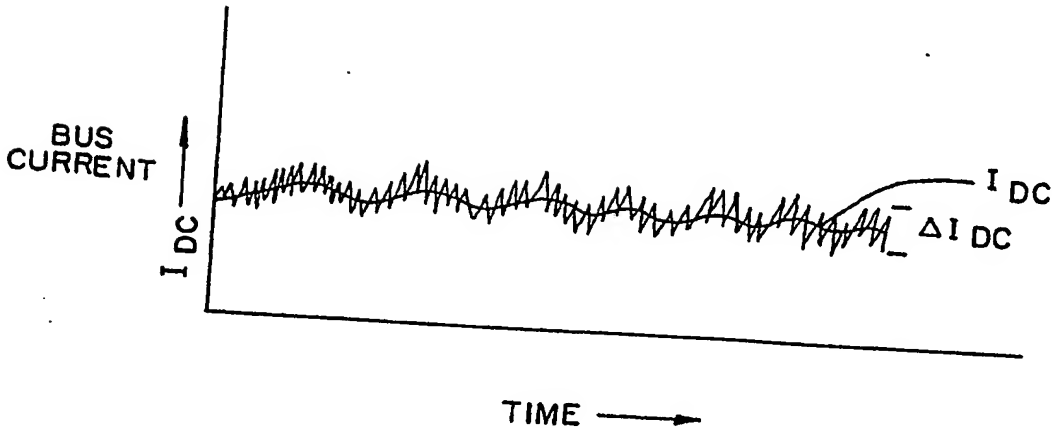
BUS CURRENT
I DC
I DC
ΔI DC
TIME

FIG. 3.

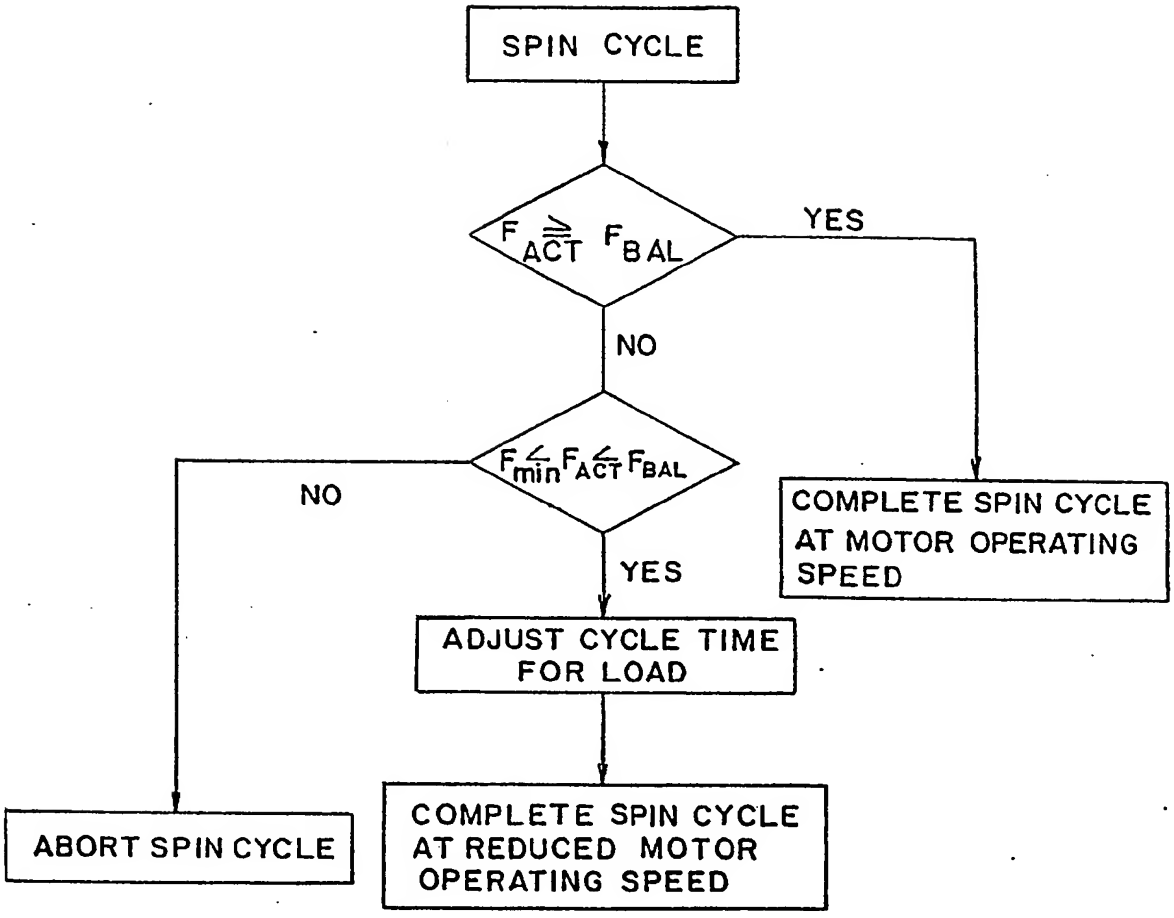

FIG. 4.